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The Reef Corals *Lithactinia* and *Polyphyllia* (Anthozoa, Scleractinia, Fungiidae): A Study of Morphological, Geographical, and Statistical Differences[1]

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ABSTRACT: The taxonomy of the Indo-Pacific reef corals *Lithactinia* and *Polyphyllia* is analyzed. They differ morphologically in that *Lithactinia* has one founder calice and no significant secondaries and has a lighter construction. A study of base area to weight ratios shows a significant difference, $P < .001$. They have a mutually exclusive geographical distribution. These data suggest that each is a valid genus.

THE SCLERACTINIAN CORAL GENUS *Polyphyllia* is represented in most major coral collections and is well known. It is widespread in the Indo-Pacific tropics, often rare, seldom common, and never abundant. Because these are free-living colonies found in shallow waters, the coralla were easily collected and transported and so are represented in many early descriptive works. Rumphius' (1750) specimen *Fungus saxeus oblongus* may have been of this genus, and Seba's (1758) *Marine taupe* certainly was, although it was not mentioned by Linnaeus (1758), whose coral specimens were largely from the Caribbean.

I have reviewed the literature on *Polyphyllia* and allied genera, and have examined many specimens so designated from many different geographical locations in situ and in various museum collections. Veron and Pichon (1979), in their monograph, conclude that *Polyphyllia* is a variable genus which "it is widely agreed" includes *Cryptobacia* and *Lithactinia*. This study was to verify or disprove that assertion.

HISTORICAL REVIEW

With the opening of the Pacific and the China trade in the eighteenth century came a surge of collections of marine specimens. Shells prized for beauty, rarity, and exotic origin fetched high prices and for a number of years trading was brisk. Many important national collections were begun at that time. Naturalists had a field day publishing descriptions of new finds in richly illustrated books. Many of these books were oriented to malacology but reef corals were at times included. Thus, Seba in 1758 illustrated the modern genera *Fungia*, *Herpolitha*, and *Polyphyllia*, and Houttuyn in 1772 produced a richly illustrated volume using the Linnean system in his designations. Among Houttuyn's specimens was a solitary coral which he named *Madrepora limax*, assuming it to be from a sea slug or mollusk. This eventually became *Herpolitha limax* Eschscholtz (1825).

Lamarck (1801) proposed the genus *Fungia* when he described *F. scutaria* and others. He included in his genus Seba's "Bonnet de Neptune" which he renamed *F. limacina*, again relating it to the mollusks. This coral eventually also became *Herpolitha*. At the same time Lamarck referred to Seba's striking drawing of *Marine taupe* as *Fungia talpina*, retaining the implication that it was from a kind of ocean mole. This coral eventually became *Polyphyllia talpina*.

René Lesson (1831) seems to have been the first naturalist to examine and illustrate a member of this group after observing the live animal in its native habitat. He named his find *Lithactinia novae-hyberniae* after the island of

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New Ireland on whose reefs he collected it in 1823. Within the decade Quoy and Gaimard (1833) returned to France with a coral collected in the same general area that they referred to as *Polyphyllia pelvis*. They questioned whether it was related to *Fungia talpa* Lamarck (1816) but equated it with *L. novae-hyberniae* of Lesson. Their description aptly fits *novae-hyberniae* as does their figure (pl 52, 9–10); however, their figure 8 appears to show the lamella they describe as perpendicular to the central sulcus as actually being parallel, suggesting that the artist may not have had the specimen in hand when the drawing was executed. I believe the illustration, however, is of a *Lithactinia* and not of a *Polyphyllia*.

The literature presents a publication paradox. Quoy and Gaimard used the genus designation *Polyphyllia* in describing *P. pelvis* in 1833. They refer to de Blainville (1830) thus—"This genus which was established by mm. Quoy and Gaimard"—who in turn cites their (Q and G) 1833 publication in his bibliography. De Blainville gives no explanation as to how he acquired these data three years before they were officially published. He lists *P. pelvis*, *P. talpa*, and four species of his own which he neither described nor figured. These specimens have been lost. De Blainville's illustration of *Polyphyllia* is apparently copied in part from Quoy and Gaimard. The remaining figure is of *Lithactinia*, similar to Lesson's pl 16, figure 3. Ehrenberg (1834) recognized *P. talpa* and attributed it to Quoy and Gaimard. He added *P. sigmoides* which he equated with Seba's *Marine taupe*, and *P. leptophylla*, which from his description is not distinquished from *P. talpa*.

Dana (1846), in a comprehensive review, arranges the *Polyphyllia* thus:

I. Medial interrupted series of orimes
   (1) *P. talpa* (3) *P. sigmoides*
   (2) *P. leptophylla* (4) *P. pelvis*

II. Orimes very distinct
   (5) *P. fungia*

III. Orimes indistinct. No medial series
   (6) *P. pileiformis* (7) *P. galeriformis*

In his text he refers to the species of both Lesson and Quoy and Gaimard as *P. pelvis*, which he believes akin to *P. talpa*. He described a new species, *P. fungia*, saying the specimen was at the Academy of Science in Philadelphia. He gave no figure, and the original specimen has apparently been lost.

Dana, who was a field naturalist, illustrated a live *Polyphyllia pileiformis* (from the Latin word for mole), its skeletal characteristics, and those of a closely related *P. galeriformis* (from Latin *galerum*, bonnet or helmet). He cited Lesson and Quoy and Gaimard and recognized the similarity among all the species, but failed to see that all the specimens he studied had been deformed by secondary growth, an observation which would have been apparent had he had an unbroken specimen.

Milne Edwards and Haime (1860) contrived the following scheme to accommodate what they believed to be three closely allied genera:

I. *Cryptobacia*: Central calices arranged in a distinct line, many secondary centers with clearly radiating septa. Type species *C. talpina* (Lamarck 1801) = *talpa* (Lamarck 1816).

II. *Polyphyllia*: Calices are of two sorts, central ones are in a line and "subradiate," while secondary centers are indistinct and do not radiate. Type species *P. pelvis* Quoy and Gaimard.

III. *Lithactinia*: All calices of one kind. No radial arrangement. Type species *L. novae-hiberniae* Lesson.

John Wells (pers. comm.) succinctly summarizes:

> The dates of publication of new genera and species must be adhered to, thus: Polyphyllia Quoy & Gaimard in Blainville 1830, *Lithactinia* Lesson 1832, and *Cryptobacia* Milne Edwards & Haime 1849. *Polyphyllia* had two syntypes: *P. pelvis* Q & G in Blainville 1830 and *P. talpa* Lamarck (= *P. talpina* Lamarck 1801). In 1849 M. E. & H. made *P. talpina* type by monotypy of their *Cryptobacia*, hence *P. pelvis* became type of *Polyphyllia* (M. E. & H. figured *P. pelvis*), and kept *Lithactinia* separate. In 1909 Gardiner in his revision of the Fungiidae gave good reasons for putting *P. pelvis* in *P. talpina* and then chucked in *Lithactinia* n-h. for good measure. I followed this consolidation in my paper on the *Fungiidae* before I had seen a proper specimen of L.n.-h., but *Lithactinia* may be a distinct genus.

Meanwhile, Duncan (1884) erected the alliance *Herpolithoida* with our similar colonial

Fungidae which had some calices incomplete and nonradiating. This included *Herpolitha*, *Polyphyllia*, *Lithactinia*, and *Zoopilus*. Gardiner (1909) based his conclusions on the examination of seven specimens he determined were *P. talpina* and four specimens described by Quelch (1886) as *Lithactinia*, which, although all showed secondary regrowth, he dismissed by saying "there is no adequate figure of any other specimen supposed to belong to *Lithactinia*." He did not alter species designations.

Folkeson (1919) described *Polyphyllia producta* on the basis of one specimen found off Cape Jaubert, E. Australia. Boschma (1925) gave measurements of 15 specimens of *P. talpina* he had examined and concluded that *P. producta* was a variant of *P. talpina*. Wells (1956) retained the classification of Gardiner, as mentioned, and observed (1966) that the septocostal structures of the subgenus *Fungia* (*Pleuractis*) are comparable to the structures of *Herpolitha*, *Polyphyllia*, and (Q.E.D.) *Lithactinia*, putting them together in an evolutionary grouping. The last collection report available with complete synonomy is Veron and Pichon (1979). They list in "material studied" 24 specimens from six locations all within the Great Barrier Reef Province.

MATERIALS

Approximately 90 corals labeled *Polyphyllia* were examined for this study. These include: my collection (AEL) 12; Bernice P. Bishop Museum, Honolulu, Hawaii (BBM) 2; Museum of Comparative Zoology, Harvard University (MCZ) 7 (including four of Dana's syntypes); Rijksmuseum van Natuurlijke Historie, Leiden (RMHS) 42; Museum National d'Histoire Naturelle, Paris (MNHN) 1 (Lamarck's specimen); United States National Museum, Washington, D.C. (USNM) 22 (including two of Dana's syntypes); John W. Wells Collection, Ithaca, N.Y. (JWW) 5.

METHODS

Methods used were similar to those outlined for a previous study on *Astreopora* Lamberts (1982*a*). More than 100 Indo-Pacific reefs were surveyed with underwater gear and the presence of fungid corals noted. Appropriate voucher specimens were labeled with numbered plastic tags, cleaned, and data entered in a sequentially numbered data book. Collection data included date, water depth and quality, current flow, underwater appearance, substrate, and general composition of the reef with percent coral cover. When possible a list of the genera and species identified gave the following informational numbers:

1. Abundant when dominant or found everywhere.
2. Common, 10–50 seen in an hour's dive search.
3. Occasional, 3–9 in an hour's search.
4. Rare, 1–2 per hour's search.

At time of classification, data from each specimen were recorded with the following additional data:

1. When possible an outline of the base covered by the specimen was measured in cm^2. The specimen was weighed on a precision balance.
2. Transillumination for obvious preforations.
3. Calices in central sulcus counted.
4. Secondary calices, primary septa, dentations, and so on evaluated.
5. Undersurface, attachment scars, and so forth, noted.
6. In a few specimens, volume was estimated by displacement of 2 mm plastic spheres.
7. Computation of weight–base area ratio for statistical evaluation.
8. Final diagnosis.

ECOLOGY

Vaughan and Wells (1943) in their revision of the Order Scleractinia included factors other than skeletal elements such as form of corallum, colony formation, and physiology. Their generic classification, however, is based primarily on the formation of the skeletal septa. Wells (1966), in a study of the evolution of fungid corals, emphasizes the microscopic similarity among the various groups and surmises that each of these groups may have had a common ancestor. One such alliance includes *Fungia* (*Pleuractis*), *Herpolitha*, *Polyphyllia*, and, by inference, *Lithactinia*. These corals are found only in the tropical Indo-Pacific but do not have the same geographical distribution. Of the four, *Pleuractis* has the widest distribution and *Lithactinia* the most restricted (Figure 1).

Fungia, *Herpolitha*, and *Polyphyllia* have been reported from many localities in the Indian Ocean south to the Tulear, Malagasy reefs (Pichon 1974) and North West Cape, West Australia (Wilson and Marsh 1979). The north limit is the Okinawa area (Yamazato et al. 1978). They are found south to Heron Island, including the Barrier Reef Province (Veron and Pichon 1979). The known eastern range of *Polyphyllia* is Ponape, Caroline Islands (Ma 1959). Both *Fungia* and *Herpolitha* are found east to the Tuamotus (Wells 1954), but only *Fungia* has been reported from the Hawaiian chain. *Lithactinia* has New Ireland as both its north and west limits, with New Caledonia and Tonga as the southern and American Samoa as the eastern limit.

Fungia (*Pleuractis*) *scutaria* Lamarck 1801 is the most abundant species of that subgenus and has been studied extensively in Hawaii where it is the only *Fungia* found. Its biology, general behavior, and reproductive strategies are probably similar to other members of the alliance, and I am presuming that it will serve as a model for all. It occurs widely, but in places other than Hawaii where *Fungia* with similar growth niches are found, it is usually rare or uncommon (Lamberts 1983).

Fungia scutaria is found on a sandy or rocky substrate in openings among general reef growth. These corals may be solitary or may occur in aggregations of hundreds of individuals. No gametes or planula larvae have been reported from any member of this group, but small developing *F. scutaria* in the early anthocaulus stage are occasionally found. Often many of these are found arising from an ancient corallum of that species. I have not been able to determine if these always arise from the living tissue of a severely stressed adult or if the *Fungia* skeleton is only a "preferred" substrate. Other corals such as *Leptoseris* have similar habits (Wells 1972). *F. scutaria* can right itself when overturned but appears to lose this capacity when it reaches its maximum size of about 20 cm length (1 kg). On one occasion I turned one member each of 15 matched pairs in a protected deep reef opening in Kaneohe Bay, Oahu, Hawaii. A week later 7 of the 15 had righted themselves but these only included the smaller ones under about 15 cm. Larger, heavier corals eventually lost their zooxanthellae and later died. Smaller specimens can migrate slowly over sand in an aquarium covering a distance of several cm a day. Specimens of *F. scutaria* are commonly found with tentacles extended during daylight hours.

Because *Herpolitha* has not been reported from areas where it might be expected does not mean it is not present. When I surveyed 14 reefs near Semporna, Sabah, East Malaysia, I systematically searched for an hour using only a face mask and found an average of 34 scleractinian genera per reef. The highest number on any one reef was 45 genera with a total of 57 genera in the area. *Herpolitha* was rare but present on eight, absent on four, and common on two, as were many other fungids. *Herpolitha* is found on semiprotected to protected reef slopes and in slightly deeper water than *F. scutaria*. It is polystomatous with a cluster of tentacles about each opening. The tentacles are merely an inflation of the membrane over the lamella around each mouth. Dana (1846) records that in some species the general tint is umber with a sprinkling of bright green. *Herpolitha* can attain a large size. Pichon (1974) gives the average or maximum as 50–60 cm.

The genera *Polyphyllia* and *Lithactinia* do not appear to have a territorial overlap, but there are virtually no reports from regions where they both might occur. *Polyphyllia* is common in certain areas of the Great Barrier Reef Province (Veron and Pichon 1979). I found it to be abundant off Mactan, Philippines, in an area where coral was harvested commercially for export. In Semporna, Sabah, I found it rare in 6 of 14 reefs, occa-

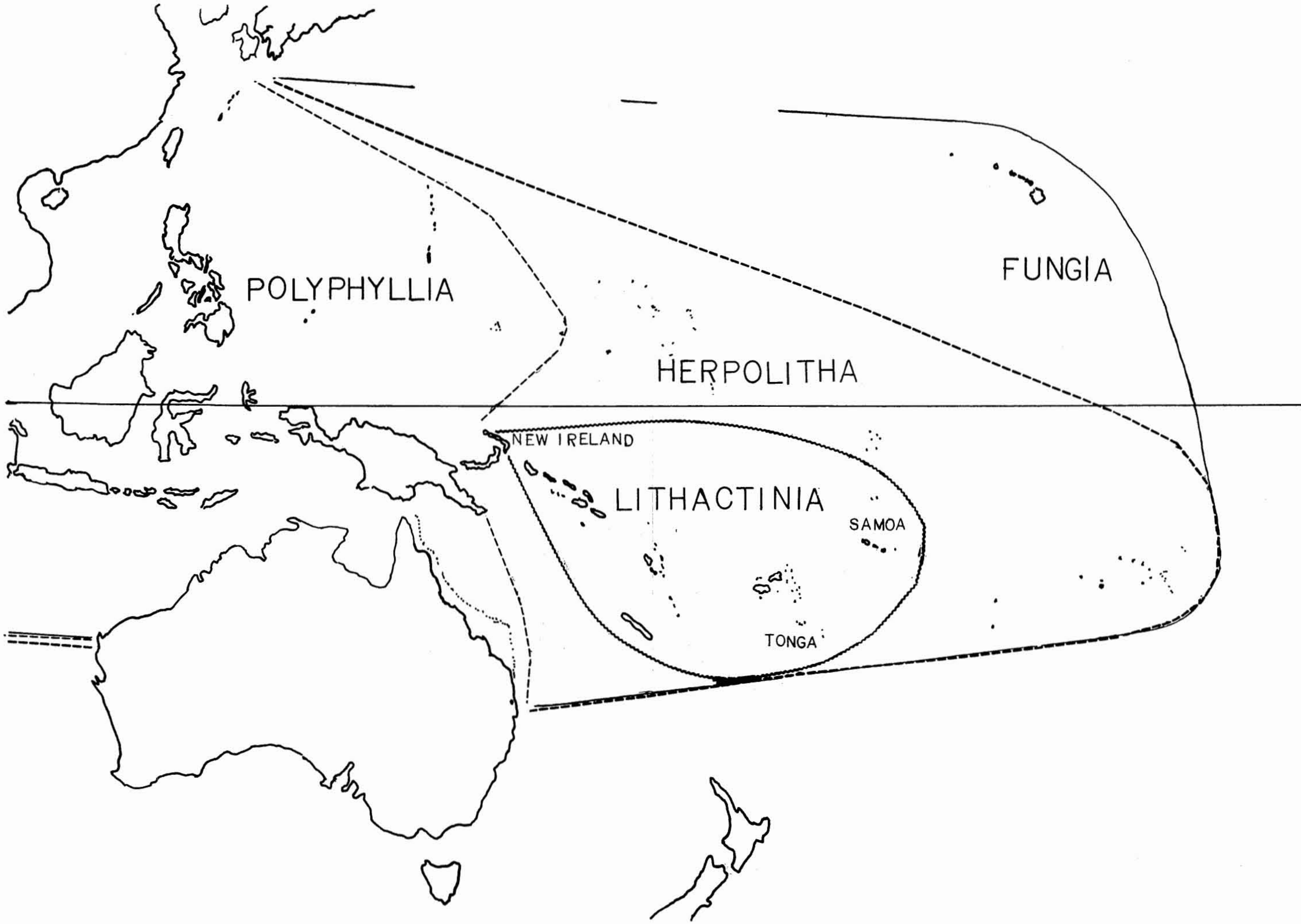

FIGURE 1. Pacific range of four reef corals: *Fungia*, *Herpolitha*, *Polyphyllia*, and *Lithactinia*.

sional on one, and common on the same reef with *Herpolitha* northeast of Pulau (Island) Bum Bum. *Acropora* was rare there. *Polyphyllia* is usually on a substrate of sediment in which mud is a dominant feature although it may be found in sand filled hollows amid coral flagstones or scattered randomly among a general coral assemblage. In general, it is a shallow-water genus, most commonly found at 1–4 m in sheltered lagoons or back reef slopes. Pichon (1974) gives a maximum size of 50–60 cm. The largest I could measure, USNM 165766 collected by F. F. Bayer in 7 m off Ifaluk, Caroline Islands, was 45.1 cm long. *Polyphyllia* is polystomatous with one mouth opening for each tentacle. The tentacles are numerous, horn shaped, up to 2 cm long, usually brown with white tips, occasionally green tinted, and extended during daylight. The name *Polyphyllia* is from the Latin meaning "many leaves" and obviously refers to the corallum; the specific epithets *talpina* or *taupe*, meaning mole, probably refer to the shaggy furry appearance on the reef.

Lithactinia is a neglected genus because its distribution is limited to a relatively small area in the southwest Pacific where few collections have been made in recent years. Lesson (1831) found his specimen on rocks in very shallow water. Quoy and Gaimard (1833) collecting in the same general area reported "Cette Polyphyllie n'est point rare dans la mer du Sud." All remark on the lightness and thinness of the corallum, and they say that the specimens are almost round and have abundant tentacles. Lesson says these are bistre color, rose-colored above and bronze below. He illustrates one central opening for nutrition. His illustration pl. 6-B is almost identical to Figure 11.

Dana illustrates a living specimen of *Polyphyllia* (*Lithactinia*) *pileiformis* showing numerous long brown tentacles. He does not say if he himself collected the specimens or if they were brought up by Fijians who collected for him. Specimens obtained by the *Challenger* expedition and described by Quelch (1886) have a note "brought alongside the ship by natives off Kandavu" (Fiji). In his review of these fungids, Gardiner (1909) deduced from sand still clinging to them that they had been picked off a sandy bottom. The *Lithactinia* I collected were all found on sand between coral mounds at depths of 2 m in still water. Individuals in one cluster of five found in Sandfly Passage, Florida Island, Solomon Islands, were within 1 m of each other and 10 m from all other coral. All were of a uniform brown color with profuse tentacles all extended in bright noon sunshine. The nearby reefs had many colonies of *Stylophora* but few *Acropora*, *Montipora*, or *Pocillopora*. I recorded no other fungids on those reefs.

SYSTEMATIC DESCRIPTIONS

This group of corals has the following systematic classification:

Order	Scleractinia	Bourne 1900
Suborder	Fungiina	Verrill 1856
Superfamily	Fungiicae	Dana 1846
Family	Fungiidae	Dana 1846

There are seven genera (Wells 1956). Of the four groups being studied *Fungia* (*Pleuractis*) and *Herpolitha* have more than one species each; here only the most common will be presented. The following characteristics are common to all: solitary, usually colonial, hermatypic, discoidal, or elongate oval. Oral surface convex. Colony formation by incomplete intratentacular polystomodeal budding. Walls synapticothecate, commonly secondarily septothecate or thickened. Septa numerous, fenestrate in early stages, later perforate or solid, composed of a single fan system of compound trabeculae producing simple or compound marginal dentations, laterally united by stout compound synapticulae. Axis of trabecular divergence horizontal in ephebic stages. Costae continuous or broken up into spinose projections. Columella trabecular and feeble. Dissepiments absent. Epitheca only in early epiblastic stages. Calices of two kinds; one series in central sulcus and secondary lateral ones. Septa and costal rays alternately thick and thin. Tentacles often out in daytime. Shallow water.

The following characteristics of *Fungia*

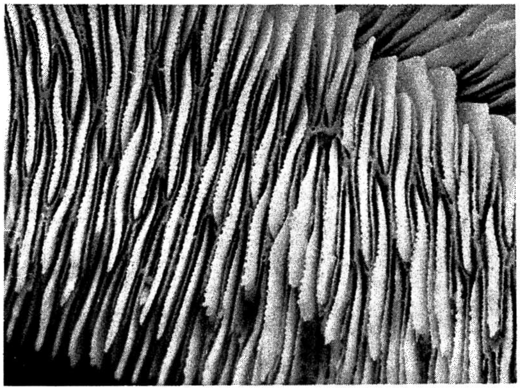

FIGURE 2. *Herpolitha limax* showing septa, ×1.5 (AEL 405).

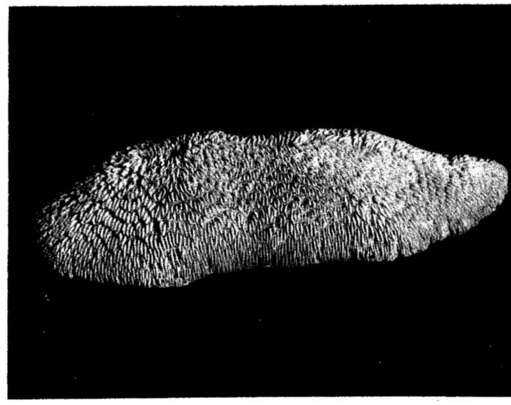

FIGURE 3. *Polyphyllia talpina*: Lamarck's specimen no. 77, ×$\frac{1}{3}$ (MNHN).

(*Pleuractis*) apply to all of this group (Wells 1966),

1. elongate corallum;
2. fine septal dentations evenly spaced, 0.5–1.0 mm;
3. costae reduced to rows of small, lightly spinose or tuberculose spines; and
4. perforate wall.

Distinct differences among these genera include:

1. number and characteristics of central calices;
2. character of secondary calices and septa;
3. differences in geographical distribution which have already been discussed; and
4. differences in coenosteal buildup giving a much heavier body weight to specimens in some genera.

Fungia (*Pleuractis*) Verrill, 1864

Fungia scutaria Lamarck, 1801. This species is well described by Gardiner (1909) and Veron and Pichon (1979) and will not be repeated here.

Herpolitha Eschscholtz, 1825

GENERIC SYNONOMY: Veron and Pichon (1979).

TYPE SPECIES: *Herpolitha limax* (Houttuyn, 1772).

Figure 2

CHARACTERS: As described by Veron and Pichon 1979.

Polyphyllia Quoy and Gaimard 1833 in Blainville 1830

GENERIC SYNONOMY: *Fungia* Lamarck, 1801 (*pars*), Oken (1815) (*pars*), Lamarck (1816) (*pars*), de Blainville (1820), Lamouroux (1824); *Agaricia* Schweigger, 1820 (*pars*); *Herpolitha* Eschscholtz, 1825 (*pars*); *Polyphyllia* de Blainville, 1830 (*pars*), 1834 (*pars*), Quoy and Gaimard (1833); *Cryptobacia* Milne Edwards and Haime, 1849; *Polyphyllia* Veron and Pichon (1979) with additional entries.

SYNONOMY: *Polyphyllia talpina* Lamarck (1801); *Fungia talpina* Lamarck (1801); *Fungia talpa* Oken (1815), Lamarck (1816), de Blainville (1820), Lamouroux (1824); *Agaricia talpa* (Oken), Schweigger (1820); *Herpolitha talpa* (Oken), Eschscholtz (1825); *Polyphyllia talpa* (Oken), de Blainville (1830, 1834), Ehrenberg (1834), Dana (1846), Ortman (1888); *Polyphyllia substellata* de Blainville, 1830, de Blainville (1834), Milne Edwards and Haime (1851, 1860); *Polyphyllia pelvis* Quoy and Gaimard, 1833, Dana (1846), Milne Edwards and Haime (1851, 1860). *Polyphyllia sigmoides* Ehrenberg 1832, Dana (1846); *Polyphyllia leptophylla* Ehrenberg 1832, Dana (1846); *Cryptobacia talpina* (Lamarck 1801), Milne Edwards and Haime

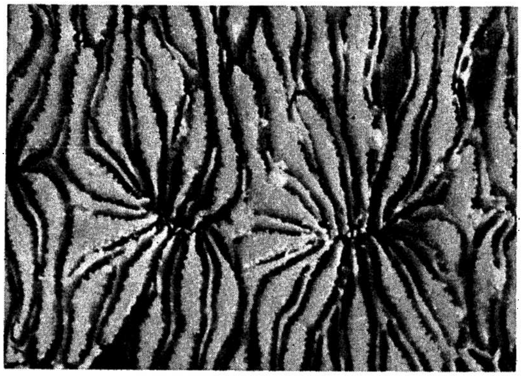

FIGURE 4. *Polyphyllia talpina* calices in lateral portion of central furrow, ×3 (AEL 1563).

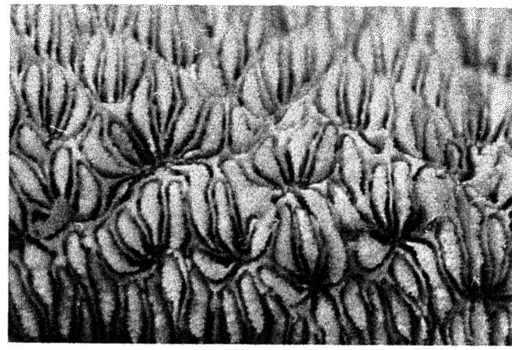

FIGURE 5. *Polyphyllia talpina*: lateral calices, ×2 (AEL 1563).

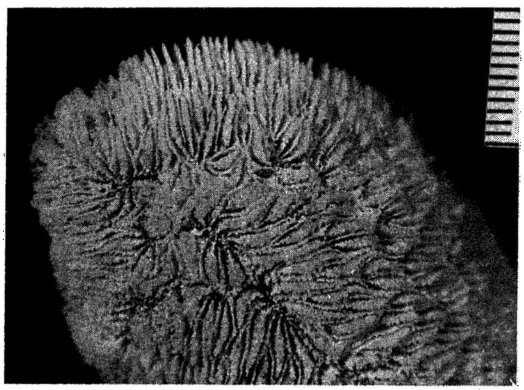

FIGURE 6. *Polyphyllia talpina*: shows calices in regenerating tip of fractured specimen, ×1½ (AEL 1569).

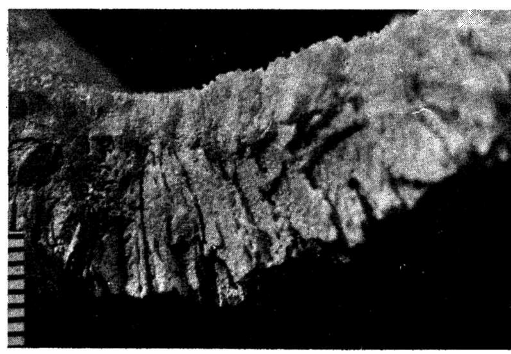

FIGURE 7. *Polyphyllia talpina*: surface of vertical fracture, ×1½ (AEL 1408).

(1851, 1860), Verrill (1864), Studer (1880), Quelch (1886), Duncan (1889), Bedot (1907); *Cryptobacia leptophylla* (Ehrenberg) Milne Edwards and Haime (1851, 1860); *Polyphyllia talpina* (Lamarck) Gardiner (1909), Boschma (1925), Faustino (1927), Ma (1959), Veron and Pichon (1979) with additional listings of *P. talpina*; *Polyphyllia producta* Folkeson, 1919.

TYPE SPECIES: *Polyphyllia talpina* (Lamarck, 1801).

Figures 3–7

CHARACTERS: A pleomorphic genus, one species known; forming elliptical coralla with a ratio of 1:2 to 1:8 and an average 1:4 breadth to length in 50 specimens measured. Usually arched in shorter diameter, this increasing with size. Smallest specimens' undersurface may be flat and these are extremely like small *Herpolitha* (Gardiner 1898). Specimens do not transilluminate. Uppersurface convex with the height being about half the breadth, less in small, greater in larger specimens. Uppersurface has central furrow usually running length of corallum. Usually a well-formed founder calice in center with about 14 lateral "centers" in a 10 cm specimen, proportionately more in longer ones. On either side, parallel to and about 1 cm from central furrow are rows of incomplete or partially formed growth centers. Further out there are more, less well formed and not arranged in an orderly manner. The

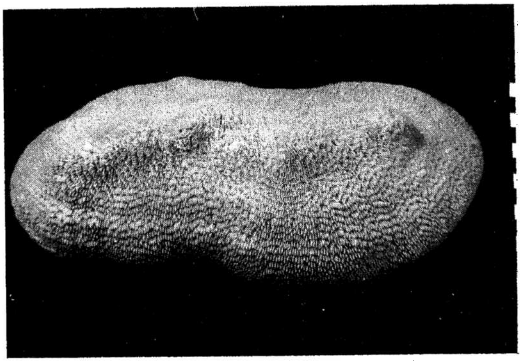

FIGURE 8. *Lithactinia novaehiberniae*: neotype, $\times \frac{1}{5}$ (USNM 61072) Tonga.

founder center has about 12 heavy and an equal number of light septa reaching the semblance of a columella, others in the central furrow have a radial arrangement but are less well organized; those in the periphera still less well organized until at the edge there are about 17 thin septa per cm parallel to each other. Presumably these are reshaped as growth continues. Most septa are alternately thick and thin. The thick septa have crescent-shaped lamella which are about 3–5 mm long each and 0.7 mm thick at intervals. These have jagged teeth and beaded ribs on both sides. They are very similar to those seen in *Lithactinia*. Between and surrounding each are the thin 0.2 mm septa which are also irregularly toothed.

The corallum is about 1.5 cm thick in mature specimens with a heavy 0.5 cm thick base. Undersurface slightly irregular, showing no costa but thickly covered with short, heavy echinulations. No well-defined growth bands, and usually no attachment scar.

MATERIAL AND COLLECTION DATA: AEL: 1408, Sabah; 1563, 1564, 1565, 1566, 1567, 1568, 1569, Mactan, Philippines. BBM: SC414, Torres Strait by Ward. USNM: 45543, Murray Is., fig. by Vaughan (1918); Steere collection, Philippines; nine unnumbered specimens. One unnumbered from Singapore; 165766, Ifilik, Caroline Is. MCZ: 25206 Warrin Reef, Torres Strait, by Ward; three unnumbered labelled Ward, Torres St.; two labelled Putnam, Singapore; another 25206. MNHN: Labelled Lamarck 77. RMHN: 8420 Kei Is., Danish Exped. (five specimens); 8419 Kei Is. (nine spec.); 8414, Banda; 8415, 8416, 8417, 8418, 8419, all Banda; 8420 Kei Is. (five spec.); 10130 Siboga Exp.; 10131, Molluca; 10132, Flores; 10133, 10134, 10135, all Indian Ocean; 10136, Ambon; 10137 Java Sea; 10138, Indian Ocean; 10139, 10140 Kei Is., Siboga Exped.; 10141 Ambon; 10142 Sumatra; 11507 Heron Is.; 13878 Timor. JWW: one specimen, unnumbered.

Lithactinia Lesson, 1831 (also listed 1832)

GENERIC SYNONOMY: *Lithactinia* Lesson, 1831, Milne Edwards and Haime (1851, 1860), Duncan (1884), Quelch (1886), Ortman (1888); *Polyphyllia* (?) Quoy and Gaimard, 1833, Dana (1846) (*pars*).

SYNONOMY: *Lithactinia novaehiberniae* Lesson, 1831.

Figures 8–15

Lithactinia novae-hyberniae Lesson, 1831; *novaehiberniae* Milne Edwards and Haime (1851, 1860), Quelch (1886), Ortman (1888); *Polyphyllia pelvis* (?) Quoy & Gaimard, 1833; *pileiformis* Dana (1846), Quelch (1886); *galeriformis* Dana (1846), Quelch (1886); *novaehiberniae* Ma (1959).

TYPE SPECIES: Holotype lost, neotypes USNM 61072, USNM 71752.

CHARACTERS: The three specimens of *Lithactinia novaehiberniae* observed that did not show evidence of breakage and regrowth marked with *. These were oval to elliptical with 1:2.25 breadth to length ratio, basin shaped, light and usually high arched. Transillumination showed myriad perforating slits from edge to central attachment scar, which appears fresh, about 8–10 mm across, surrounded by a small elliptical area of coenosteal deposition. On the convex uppersurface directly opposite is the founder calice, sometimes two, in the horizontal central furrow which runs about half the length and ends where a sharp descent begins. Central calice has 10–12 thick septa reaching the weak trabecular columella, alternating with smaller thin septa. The central furrow is

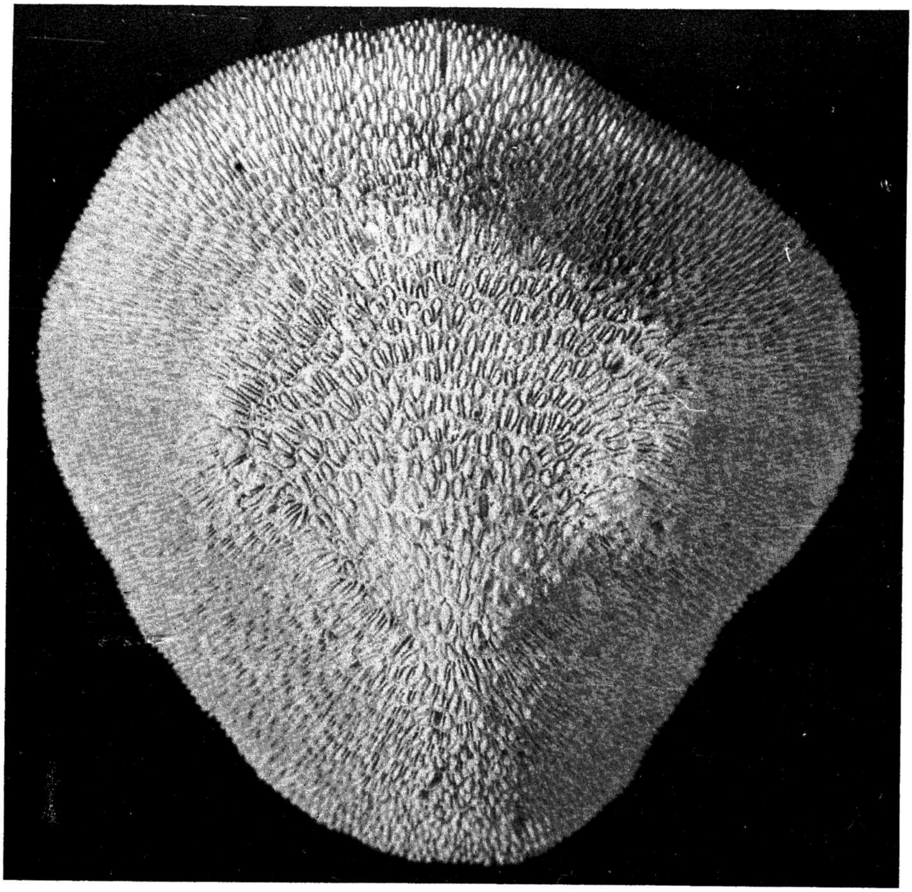

FIGURE 9. *Lithactinia novaehiberniae*: neotype, natural size (USNM 71752); Solomon Islands (AEL 1529).

bridged by alternating pairs of thick and thin lamellar septa meeting at an obtuse angle in the center, occasionally arranged to suggest partially formed calices. Septa can be traced from central furrow to the edge which they meet perpendicularly about 17–18 per cm.

Alternate septa thicken at regular intervals forming crescentic lamella which project slightly outward. These are about 3.5 mm long and 0.7 mm wide, jaggedly toothed and beaded on the sides. Between are thin septa, 0.2 mm wide, less conspicuous, which fuse around the ends of the lamella. Occasionally two or three thick lamella seem to join at their upper end, but nowhere are there calices other than in the central furrow. The concave

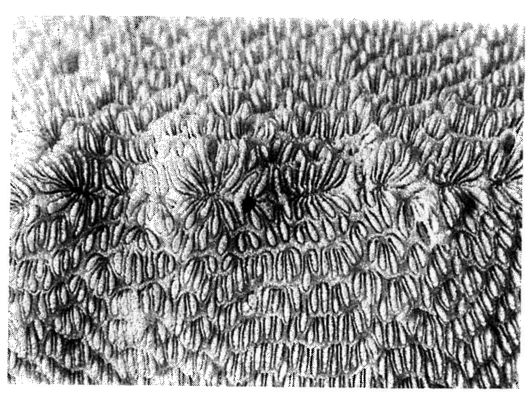

FIGURE 10. *Lithactinia novaehiberniae*: founder calice, slightly enlarged (RMHN 14098).

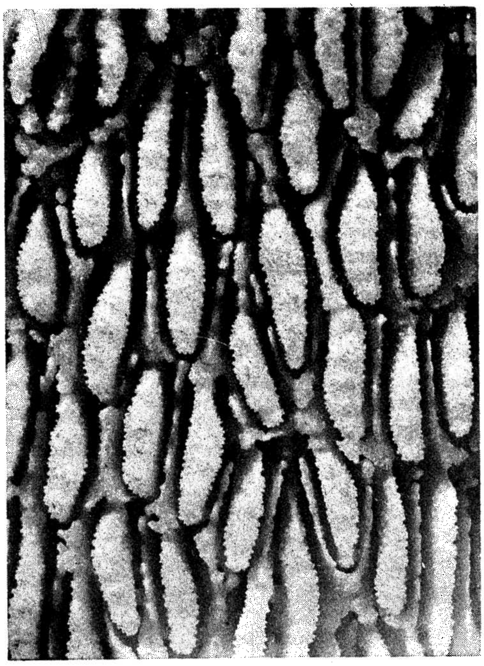

FIGURE 11. *Lithactinia novaehiberniae*: lateral lamellae, ×4 (AEL 1529).

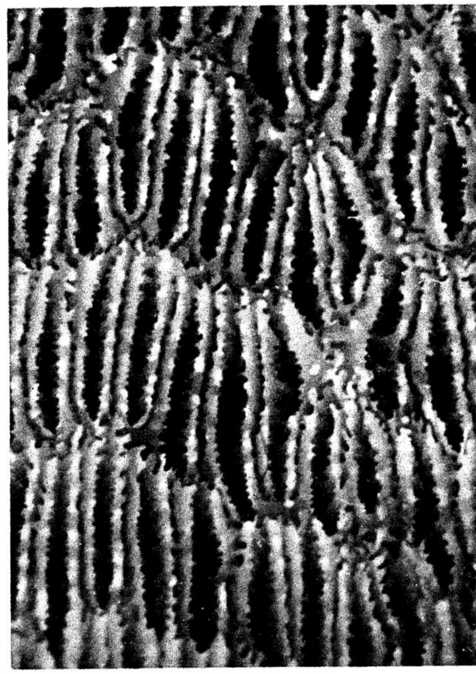

FIGURE 12. *Lithactinia novaehiberniae*: lamellae outlined by transillumination, ×4 (AEL 1525).

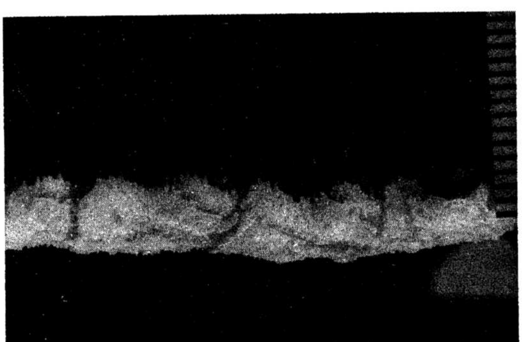

FIGURE 13. *Lithactinia novaehiberniae*: surface of vertical fracture, ×2 (USNM, Thompson specimen).

undersurface has concentric waves, probably from irregular growth (also well seen by transillumination), which measure 0.5–0.6 cm between crests. Surface has costae consisting of rows of fine beading.

The remainder of specimens do not show a central furrow. All show variations of regeneration from a small piece of corallum wall which has grown from all sides thus developing into a basin shaped structure with the original fragment more or less parallel to the substrate.

MATERIAL AND COLLECTION DATA: AEL: 1525, 1526, 1527, 1528, Solomon Is., 2 m still water; 1529 same, collected by Paul Lamberts. BBS: unnumbered specimen labelled only *Polyphyllia*. RMHN: * 14098, collected by Maya Wijsman-Best, 1976, outer barrier, 20–30 m, New Caledonia. MCZ: Dana's type #553, labelled *P. pileiformis*; Dana's type *P. galeriformis*, unnumbered. USNM: Dana's syntype *P. pileiformis* #158, #980, both from "Feejee;" Dana's syntypes *P. galeriformis* #155, #156, "Feejee;" * Tonga, collected in 2m, USNM 61072; Thompson collection, American Samoa, one fragmented specimen; New Caledonia specimens 1, 2 and 3, no data. JWW: Weber's specimen #422, labelled Tonga, 1972; * 1714, New Caledonia, 20 cm, still water, 1971; #66, #67, Fiji.

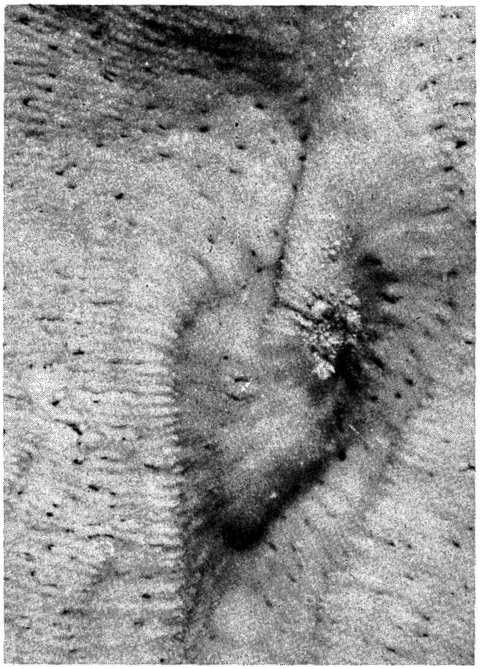

FIGURE 14. *Lithactinia novaehiberniae*: undersurface showing attachment scar, ×2 (Wells specimen no. 1714).

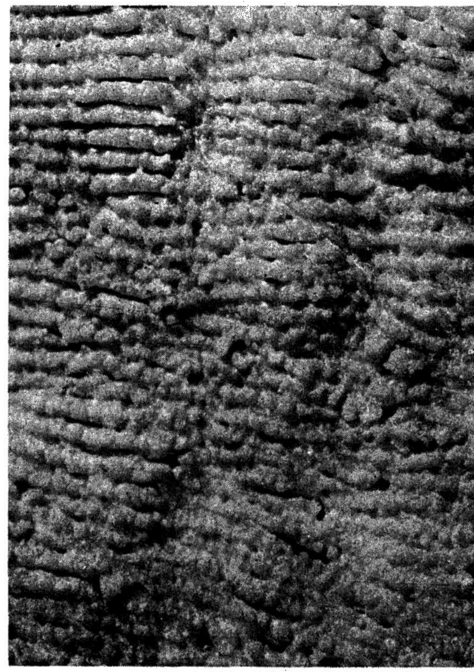

FIGURE 15. *Lithactinia novaehiberniae*: undersurface showing costae, ×4 (Wells specimen no. 1714).

STATISTICAL COMPARISONS

A statistical analysis of the two genera, *Lithactinia* and *Polyphillia*, was done to determine if this approach could be used as a valid means of separation. All available study specimens were weighed and the base areas were determined. The weight–base area ratio was calculated for each (Table 1). A Welch t test (Klecka 1980) was used to compare ratios because of the marked difference in variance within the two groups. The means of the ratios were significantly different and the calculations showed $t = 7.11$ for $df = 32$, and $p < .001$. Figure 16 shows the distribution of the two groups on the ratio variable. There is a limited overlap. In two instances the overlap was due to the small size of specimens of *P. talpina*, which are very lightly structured when young. One instance of overlap in the opposite direction was attributable to the largest and heaviest *L. novaehiberniae* specimen of the series. The analysis suggests that the value of the ratio variable can be useful in discriminating genera.

My collection of *Herpolitha* was too small for statistical analyses. However, the five specimens I possess range from a ratio of 1.64 for a 5.5 × 37 cm specimen identified as *H. stricta* Dana to 6.20 for a 7 × 18 cm specimen of *H. crassa* Dana. The average weight–base area ratio was 4.07 for all. This was higher than the mean for *Polyphyllia talpina*. In my collection of *Fungia scutaria*, a juvenile 4.4 × 3.6 cm specimen had a ratio of 1.5 whereas the ratio in a massive *F. scutaria* var. *oahensis* was 6.73.

DISCUSSION

Reef coral species often intergrade so no clear cut distribution can always be made among various specimens in any sizable collection. The continuum of the so-called identifying features among closely allied groups can be so vexing that workers such as Wood-Jones (1907) gave up and concluded that all *Pocillopora* were merely growth forms of one

TABLE 1

DATA ON WEIGHTS AND BASE AREA OF 44 CORAL SPECIMENS IN STUDY OF FEASIBILITY OF A STATISTICAL SEPARATION OF TWO GENERA

NO.	COLLECTION AND NO.		WEIGHT (g)	BASE AREA (cm^2)	RATIO
			Polyphyllia talpina		
1.	AEL	1408	141.5	49.78	2.84
2.	AEL	1563	200.	79.66	2.51
3.	AEL	1564	85.	35.	2.43
4.	AEL	1565	136.7	66.27	2.06
5.	AEL	1566	194.5	72.36	2.69
6.	AEL	1567	145.5	65.42	2.22
7.	AEL	1568	38.	22.76	1.67
8.	AEL	1569	32.	20.52	1.56
9.	USNM	45543	734.	159.43	4.60
10.	USNM	Str. 179	826.15	213.52	3.87
11.	USNM	Str. 4	1,219.	201.75	6.04
12.	USNM	Str. 5	630.	128.67	4.09
13.	USNM	Str. 6	839.	204.15	4.11
14.	USNM	Str. 7	214.	81.03	2.69
15.	USNM	Str. 8	787.5	190.09	4.14
16.	USNM	Str. 9	596.	116.57	5.11
17.	USNM	Str. 10	261.	90.6	2.88
18.	USNM	Str. 11	35.	27.74	1.26
19.	USNM	Singapore	1,028.	247.9	4.15
20.	USNM	165766	2,258.12	488.13	5.04
21.	JWW		13.35	13.29	1.00
22.	MCZ	25206	460.6	168.46	2.73
23.	MCZ	Wards	1,169.7	344.54	3.39
24.	MCZ	25206	1,644.2	279.79	5.88
25.	MCZ	Wards	1,701.	499.3	3.40
26.	MCZ	Wards	760.	295.3	2.57
27.	MCZ	Putnam	130.2	66.89	1.95
28.	MCZ	Putnam	152.	70.25	2.16
			Lithactinia novaehiberniae		
1.	AEL	1525	547.	420.15	1.302
2.	AEL	1526	30.	37.5	.8
3.	AEL	1527	41.35	55.63	.743
4.	AEL	1528	36.7	43.48	.844
5.	AEL	1529	120.7	96.	1.25
6.	BBM		120.	102.32	1.173
7.	USNM	Samoa	485.5	623.32	.7789
8.	USNM	New Cal 1	100.	111.33	.898
9.	USNM	New Cal 2	71.	77.6	.915
10.	USNM	New Cal 3	109.	109.29	.997
11.	USNM	Dana 980	81.	61.67	1.312
12.	USNM	Dana 156	120.	94.12	1.275
13.	USNM	*Tonga	745.	379.04	1.97
14.	MCZ	Dana 533	42.	39.59	1.06
15.	MCZ	Dana	290.6	207.02	1.25
16.	RMNH	* 14098	300.	240.10	1.25

GENUS	MEAN OF RATIO	STANDARD DEVIATION
Polyphyllia	3.180	1.30
Lithactinia	1.114	.288

NOTE: blank space = no number assigned; asterisk = specimen with no evidence of fracture and secondary growth.

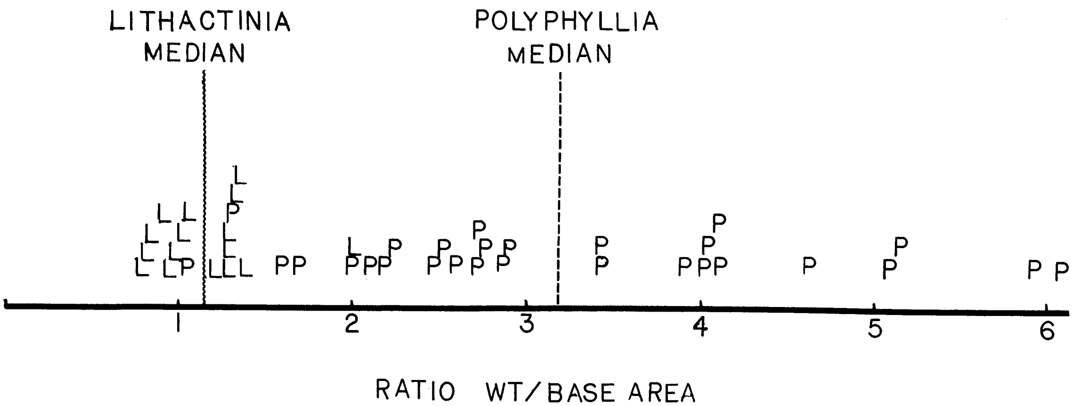

FIGURE 16. Distribution of 16 specimens of *Lithactinia novaehiberniae* (L) and 28 specimens of *Polyphyllia talpina* (P) according to weight–base area ratios.

variable genus and that species designations were meaningless. It is now generally agreed that species do exist but that there are populations of corals with morphological characteristics which may overlap with other populations. Thus, one specimen can at times be designated as one of several species, depending on the bias of the observer. With a sample of sufficient size such problems become less urgent, but there usually remain some puzzling specimens that will not fit in any scheme. A taxonomist may be tempted to ignore these if he has a sufficient sample of well-defined specimens. Confusion arises where there are few examples, and he may do as Bernard (1896) did. Whenever Bernard encountered an *Astreopora* with a slightly different growth form he erected a new species until he had eight represented by only the holotype. These problems will remain with us until we refine our methods of identification.

Generic differences are more distinct. By definition a genus is recognized where there is a decided gap from one taxon to the next (Mayr 1969). However, the same dilemma occurs when immature specimens are encountered. Gardiner (1898) noted this when he found young specimens of *Herpolitha* and *Polyphyllia* to be extremely alike. Virtually all of the fungid corals I have examined show this tendency. Earlier museum workers were faced with defining a genus on the basis of a single specimen or a species from a published drawing. The often sketchy descriptions they gave were inadequate for later revisionists who, finding these, tended to force them into their own classification mold, seemingly almost to dispose of them. In reviewing the problem, Wijsman-Best (1972) admits that even some of the larger subdivisions such as the subfamilies Faviinae and Montastreinae are rather artificial and not recognized by all workers. But by working with large suites from as many habitats as possible, using specimens from many geographical areas and noting differences in growth patterns of the various corals, a more exact delineation may be possible.

CONCLUSIONS

With data obtained from various collections, combined with observations on morphological differences and with statistical analysis, *Lithactinia* and *Polyphyllia* become distinct and, in my opinion, can be recognized as separate genera. *Lithactinia* usually has one founder calice in a central furrow, no secondary centers, and a distinct attachment scar; *Polyphyllia* has many centers in a central furrow and many secondary centers, and the attachment scar is obliterated. *Lithactinia* has less dense coenosteum, multiple perforations and transilluminates well. Statistical analyses of the ratio between weight and base area show that this feature alone separates *Lithactinia* from *Polyphyllia* with a probability of $p < .001$. There is no significant intergrading. Finally, the geographical range of *Lithactinia*, as now recognized, does not overlap that of *Polyphyllia*.

As with all biological collections there are exceptions to the general order, specimens which appear to be transitional between groupings. Thus, Lamarck's no. 77, *Polyphyllia talpina*, has a weight-base area ratio of 1.83, and most of the characters are those of *Polyphyllia*. However, it is not symmetrical, shows signs of irregular growth, and has a growth scar. The place of origin is given as the Indian Ocean. Much confusion has arisen because of the lack of representative material in the past. Fortunately, Lamarck did not present a figure or a complete description of this, his only specimen.

ACKNOWLEDGMENTS

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